YTU Physics Department, 2016-2017 Fall Semester			Exam Date: 27 October 2017			Exam Time: 90 min.	
FIZ1001 Physics-1 Midterm-I			P1	P2	P3	P4	TOTAL
Name Surname							
Registration No							
Department							
Group No	Exam Hall	Signature of the Student	The 9th article of Student Disciplinary Regulations of YÖK Law No.2547 states ***"Cheating or helping to cheat or attempt to cheat in exams"*** **de facto perpetrators takes one or two semesters suspension penalty.** Calculators are not allowed. Do not ask any questions about the problems. There will be no explanations. Use the allocated areas for your answers and write legible.				
Lecturer's Name Surname							

PROBLEM 1

(i) The motion of a particle is defined by $v_x = 50 - 16t$ (m/s) and $y = 100 - 4t^2$ (m) where t is in seconds. It is also known that $x = 0$ when t=0. **Determine the position $\vec{r}$, velocity $\vec{v}$ and acceleration $\vec{a}$ vectors at $t = 2s$.**

$\boxed{\vec{r} = x\hat{\imath} + y\hat{\jmath}}$ 1 $y = 100 - 4t^2$

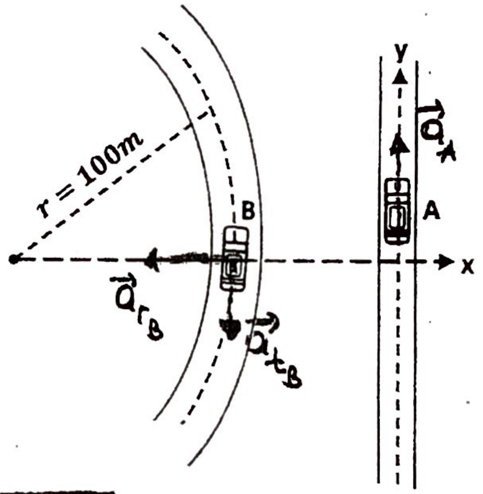
$$x = \int v_x \, dt$$
$$x = \int_0^t (50 - 16t)\, dt$$
$$x = 50t - 8t^2$$
3

$$\vec{r} = (50t - 8t^2)\hat{\imath} + (100 - 4t^2)\hat{\jmath}$$
$$\vec{r}(t=2) = 68\hat{\imath} + 84\hat{\jmath} \quad (m)$$
2

$$\vec{v} = \frac{d\vec{r}}{dt} = (50 - 16t)\hat{\imath} - 8t\hat{\jmath}$$
$$\vec{v}(t=2) = 18\hat{\imath} - 16\hat{\jmath} \quad (m/s)$$
3

$$\vec{a} = \frac{d\vec{v}}{dt} = -16\hat{\imath} - 8\hat{\jmath}$$
$$\vec{a}(t=2) = -16\hat{\imath} - 8\hat{\jmath} \quad (m/s^2)$$
3

(ii) For the instant presented in the following figure, car A has a speed of 108 km/h which is **increasing** at a rate of 7.2 km/h each second. Simultaneously, car B also has a speed of 72 km/h as it rounds the turn and is **slowing down** at the rate of 7.2 km/h each second. **Determine the acceleration of car B relative to car A** in terms of unit vectors and in SI unit system.



$\boxed{\vec{a}_{BA} = \vec{a}_B - \vec{a}_A}$ 2

$\boxed{\vec{a}_B = \vec{a}_{r_B} + \vec{a}_{t_B}}$ 1

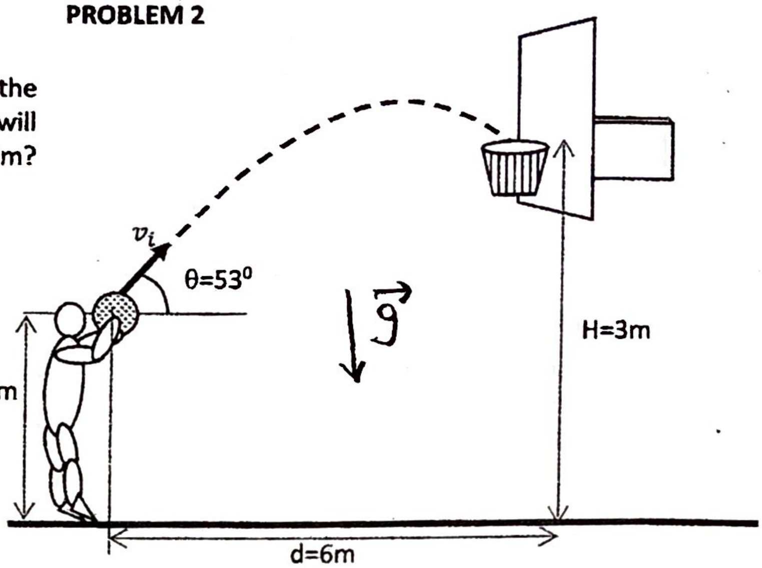
$$\vec{a}_{t_B} = 7.2(-\hat{\jmath})\left(\frac{km}{h \cdot s}\right) = -2\hat{\jmath} \quad (m/s^2)$$
$$v_B = 72\, km/h = 20 \quad (m/s)$$
$$\vec{a}_{r_B} = \frac{v_B^2}{r}(-\hat{\imath}) = -4\hat{\imath} \quad (m/s^2)$$
$$\vec{a}_B = -4\hat{\imath} - 2\hat{\jmath}$$
5

$\boxed{\vec{a}_A = 7.2\hat{\jmath}\left(\frac{km}{h \cdot s}\right) = 2\hat{\jmath} \quad (m/s^2)}$ 2

$\boxed{\vec{a}_{BA} = -4\hat{\imath} - 2\hat{\jmath} \quad (m/s^2)}$ 3

PROBLEM 2

The basketball player shots at an angle $\theta = 53^0$ to the horizontal as shown in the figure. **What initial speed v_i will** cause the ball to pass through the center of the rim? $\left(g = 10\frac{m}{s^2}\ ,\ Cos53 = 0.6\ ,\ \text{Sin}\,53 = 0.8\right)$



$$x = v_{ix} \cdot t$$

$$x = v_i \cos\theta\, t$$

$$6 = v_i\, 0.6\, t$$

5

$$t = \frac{10}{v_i}$$

2

$$y = y_0 + v_i \sin\theta\, t - \frac{1}{2} g t^2$$

$$3 = 2 + v_i\, 0.8\, t - \frac{1}{2} 10 t^2$$

$$1 = \cancel{v_i}\, 0.8 \frac{10}{\cancel{v_i}} - 5 \frac{10^2}{v_i^2}$$

or

8

$$y = v_i \sin\theta\, t - \frac{1}{2} g t^2$$

$$1 = v_i\, 0.8\, t - \frac{1}{2} 10 t^2$$

$$1 = \cancel{v_i}\, 0.8 \frac{10}{\cancel{v_i}} - 5 \frac{10^2}{v_i^2}$$

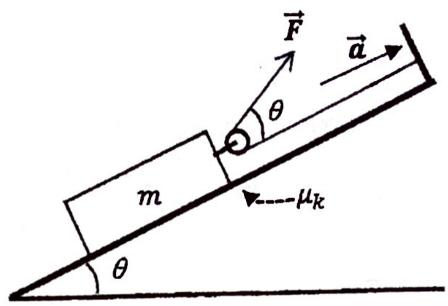
$$1 = 8 - \frac{500}{v_i^2}$$

$$v_i = \sqrt{\frac{500}{7}} = 10\sqrt{\frac{5}{7}}\ (m/s)$$

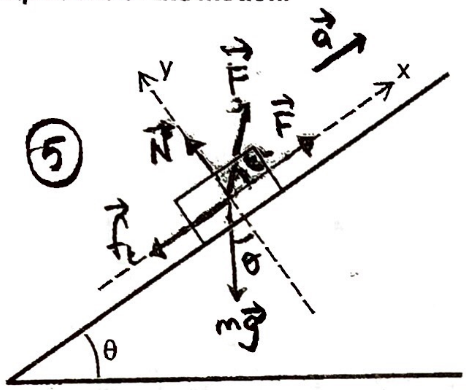
10

PROBLEM 3

A block of mass $m = 30$ kg is placed on an incline of a horizontal angle of $\theta = 37^0$. The block is pulled by a constant force $\boldsymbol{F}$ with an accelaration of $a = 2m/s^2$ in the direction as shown in the figure. The cable and pulley are weightless. The kinetic friction between the block and the incline is $\mu_k = 1/3$ ($g = 10\frac{m}{s^2}$, $Cos37 = 0.8$, $Sin37 = 0.6$).



a) **Draw free body diagram of the block and write the equations of the motion.**



(5) (6)

$$\boxed{\sum F_x = F + F\cos\theta - f_k - mg\sin\theta = ma \quad (1)}$$

$$\sum F_y = N + F\sin\theta - mg\cos\theta = 0 \quad (2)$$

(5)

$$N = mg\cos\theta - F\sin\theta \quad (3)$$

$$\boxed{f_k = \mu_k N = \mu_k (mg\cos\theta - F\sin\theta) \quad (4)}$$

(3)

b) **Find the force $\boldsymbol{F}$ in the cable.**

put eq.(4) into eq.(1).

$$F + F\cos\theta - \mu_k(mg\cos\theta - F\sin\theta) - mg\sin\theta = ma$$

$$F(1 + \cos\theta + \mu_k \sin\theta) = mg(\mu_k \cos\theta + \sin\theta) + ma$$

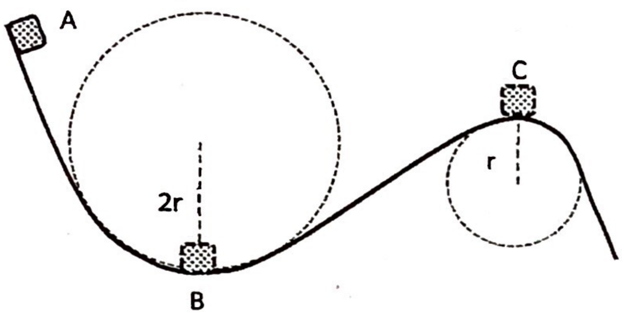
$$F = \frac{mg(\mu_k\cos\theta + \sin\theta) + ma}{1 + \cos\theta + \mu_k\sin\theta}$$

$$F = \frac{300(\frac{1}{3}0.8 + 0.6) + 60}{1 + 0.8 + \frac{1}{3}0.6} = 160\,N$$

(6)

PROBLEM 4

(i) An object at rest starts its motion from point A on a frictionless curved track. The object continues its motion passing from point B and C. The **normal force** acting by the track on the object is twice of its weight at point B and is half of its weight at point C. **Find the ratio of the speeds at point B and C, $\frac{v_B}{v_C}$.**



at point B $\Rightarrow$ $N_B = 2mg$

at point C $\Rightarrow$ $N_C = \frac{mg}{2}$

For point B

$$N_B - mg = m\frac{v_B^2}{2r}$$

$$2mg - mg = m\frac{v_B^2}{2r}$$

$$v_B^2 = 2gr$$

5

For point C

$$mg - N_C = m\frac{v_C^2}{r}$$

$$mg - \frac{mg}{2} = m\frac{v_C^2}{r}$$

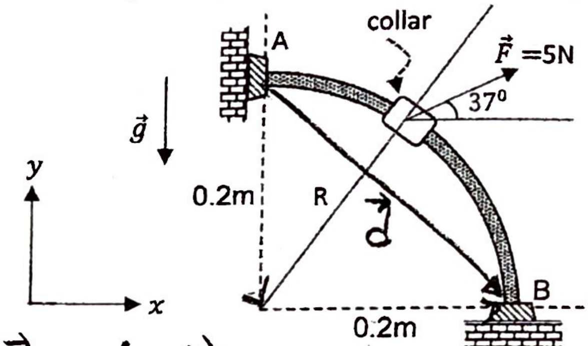
$$v_C^2 = \frac{1}{2}gr$$

5

$$\frac{v_B^2}{v_C^2} = \frac{2gr}{\frac{1}{2}gr} = 4 \Rightarrow \frac{v_B}{v_C} = 2$$

2

(ii) The 0.5 kg collar starts from rest at A and slides with negligible friction on the fixed rod in the vertical plane. **Determine the velocity v_B with which the collar strikes end B** when acted upon by the 5N force, which is constant in direction $\left(g = 10\frac{m}{s^2},\ Cos37 = 0.8\ ,\ Sin37 = 0.6\right)$.



$$\vec{d} = 0.2(\hat{i} - \hat{j})$$

$$W_{total} = W_{mg} + W_F = \Delta K$$

$$W_{mg} = m\vec{g}\cdot\vec{d} = mg(-\hat{j})\cdot 0.2(\hat{i}-\hat{j})$$

$$W_{mg} = mgd = 0.5 \cdot 10 \cdot 0.2 = 1\,J$$

3

$$W_F = \vec{F}\cdot\vec{d}$$

$$\vec{F} = F(\cos 37\hat{i} + \sin 37\hat{j})$$

$$\vec{F} = 4\hat{i} + 3\hat{j}\ (N)$$

$$W_F = (4\hat{i} + 3\hat{j})\cdot(0.2\hat{i} - 0.2\hat{j})$$

$$W_F = 0.8 - 0.6 = 0.2\,J$$

5

$$W_{total} = \Delta K = \frac{1}{2}mv_B^2 - 0$$

$$1.2 = \frac{1}{2}0.5v_B^2$$

3

$$v_B = \sqrt{4.8}\ m/s$$

2